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CUSHION FOR AN AIRCRAFT SEAT

This invention relates to a cushion suitable for use in an aircraft seat.

There is a constant desire within the aviation industry to increase the efficiency of air travel. One approach to achieve this objective is to minimise the weight of aircraft components with the ultimate aim of reducing the fuel consumption of aircraft. Accordingly, a great deal of effort has focussed on reducing the weight of a whole range of aircraft components, including aircraft seat cushions.

Conventional aircraft seat cushions consist of a moulded foam structure provided with a fabric cover. The moulded foam structure is typically formed from a polyurethane-based foam. To enable the cushion to meet stringent flammability requirements that are prescribed by the aviation industry, such as the Federal Aviation Authority and equivalent national organisations, a flame retardant is incorporated into the foam formulation and, in some cases, an additional flame retardant interliner is also provided around the foam structure.

The weight of an aircraft seat cushion is principally governed by the density of the foam used to form the foam structure. The polyurethane-based foams used in the preparation of current aircraft seat cushions typically have densities within the range of 40 to 65 kg/m^3. Accordingly, attempts to reduce the weight of aircraft seat cushions have focussed on the use of lower density foam materials. However, lower density foam materials tend to have poor physical and

mechanical properties, which results in the comfort and support provided by the cushion being compromised.

Therefore, it is an object of the present invention to provide an aircraft seat cushion which (i) is relatively lightweight (when compared with conventional aircraft seat cushions); (ii) meets the prescribed regulatory requirements with respect to flammability; and (iii) provides adequate support and comfort for a passenger sitting in the aircraft seat.

According to a first aspect of the present invention there is provided a cushion suitable for use in an aircraft seat, said cushion comprising a foam structure having a first region of a low-density flame retardant foam, a second region of a flame retardant polyurethane foam and a sealing barrier disposed at the interface between said first and second regions.

The weight of the cushions of the present invention is significantly reduced when compared with the weight of a conventional aircraft seat cushion. Furthermore, the polyurethane foam constituent of the cushion provides adequate support to the lightweight foam structure to enable a person sitting on the aircraft seat to be supported with an acceptable level of comfort.

The foam materials can also be selected to provide a cushion which meets the regulatory requirements of the aviation industry. Specifically, both the low-density flame retardant foam and the polyurethane flame retardant foam must satisfy the 'Vertical strip burner test' (Federal Aviation Regulation (FAR) 25.853a, Part 1, Appendix F) prescribed by the Federal Aviation Authority, as

well as the 'Airbus industries' smoke and toxicity requirements (Airbus Directive (ABD) 0031). Furthermore, the cushion of the present invention must also satisfy the prescribed requirements of the 'Kerosene burner test' (Federal Aviation Regulation (FAR) 25.853c, Part 2, appendix F). In brief, the FAR 'Vertical strip test' measures burn length and after-flame time, the FAR 'Kerosene burner test' measures the weight loss and burn across, and ABD0031 measures smoke obscuration and toxicity indices of the foam. A person skilled in the art will be familiar with the aforementioned requirements prescribed in the ABD and FAR.

It shall also be understood that by "foam structure" we mean the foam constituent of the cushion. In most cases the foam structure will be a moulded foam structure having a base or back surface and edges that are shaped and contoured to fit into the aircraft seat structure. In addition, the foam structure provides a support surface which, in use, forms the surface of the foam structure, which supports the body of the person sitting in the seat. The support surface of the foam structure is preferably formed by the flame retardant polyurethane foam (i.e. the second region preferably forms the support surface). In addition, it is also preferred that the all of the edges of the foam structure are formed by the flame retardant polyurethane foam (i.e. the second region forms the support surface and the edges of the foam structure).

The low-density foam material may form the base and/or the core of the foam structure of the cushion. It is especially preferred that the low-density foam forms an inner core within the foam structure which is encapsulated by an outer layer of the flame retardant polyurethane foam (i.e. the second region encapsulates

the first region). This arrangement is particularly advantageous because the flame retardant polyurethane foam provides the necessary support to the inner core of the low-density foam, thereby providing sufficient comfort and support to a person sitting in the aircraft seat.

The foam structure of the cushion will normally be provided with an outer fabric cover prior to use.

The sealing barrier is necessary to separate the flame retardant polyurethane foam from the low-density foam during manufacture. The flame retardant polyurethane foam is usually applied to the low-density foam in the form of a liquid and, in the absence of the sealant barrier, the liquid polyurethane foam tends to seep into the pores of the low-density foam. This results in the formation of a high-density interface between the polyurethane foam and the low-density foam, which in turn causes an increase in the weight of the foam structure ultimately formed. Any suitable barrier material could be used to form the sealing barrier, such as a polyethylene or a polyvinylchloride film (e.g. Clingfilm™). Preferably, however, the sealing barrier is a layer of a spray-on sealant, such as, for example, a spray-on polyurethane or PVC sealant, which is applied to the surface of the low-density foam prior to the application of the flame retardant polyurethane foam.

The reduction in the weight is achieved by replacing a proportion of the polyurethane foam that is present in conventional aircraft seat cushions with a low-density flame retardant foam. Preferably, the ratio of the volume of the low-

density foam to the volume of the polyurethane foam in the foam structure is within the range of 20:80 to 80:20 (volume to volume), with a ratio of 50:50 (volume to volume) being most preferred.

The expression "low-density flame retardant foam" is used herein to denote a flame retardant foam material having a density of within the range of 5 to 15 kg/m^3. Preferably, the low-density foam is Melamine foam that has a density within the range of 8 to 12 kg/m^3. An especially preferred form of Melamine foam is that produced by BASF and sold under the trade name BASOTECT™.

The expression "flame retardant polyurethane foam" is used herein to denote any polyurethane (PU) foam which is sufficiently flame retardant to satisfy the regulatory requirements prescribed for use in the aviation industry. Preferably, the PU foam has a density within the range of 30 to 70 kg/m^3, with densities in the range of 40 to 65 kg/m^3 being most preferred.

In a first preferred embodiment of the present invention the flame retardant polyurethane foam is a graphite/PU foam composition. The graphite/PU foams can be produced either as a moulded foam structure or as a block foam for conversion. In the case of the block foam conversion process, a slabstock foam produced in large blocks is cut into sheets and shapes which are then stuck together to form the relevant parts of the foam structure of the aircraft seat cushion. The PU foam base is a high resilience foam system, i.e. it is produced by the reaction of high molecular weight (typically 5,000 to 6,000 Mwt.) polyether polyols with toluylene diisocyanate (TDI) and/or diphenylmethane diisocyanate

(MDI) in the presence of water, catalysts and stabilisers. The required flame retardancy is imparted by the inclusion of expandable flakes of graphite in the PU foam base. The use of expandable graphite flakes as a flame retardant in PU foams is described in several patents, including GB 2168706 (Dunlop Co. Ltd), US 4,698,369 (Dunlop) and US 5,169,876 (Metzeler Schaum GmbH), the entire contents of which are incorporated herein by reference. In addition to the graphite flakes, the graphite/PU foam may also incorporate additional flame retardant additives, such as, for example, the chlorinated phosphate esters.

It is especially preferred that the graphite/PU foam is a foam that is sold under the trade name Metzoprotect™ by Kay-Metzeler Limited, U.K. Metzoprotect™ foams meet the current Federal Aviation Authority requirements with respect to flammability, namely the 'Vertical strip burner test' (FAR 25.853a, Part 1, Appendix F), as well as the 'Airbus industries' smoke and toxicity requirements (ABD 0031). In addition, Metzoprotect™ foams can also be used to form aircraft seat cushions which satisfy the prescribed requirements of the 'Kerosene burner test' (FAR 25.853c, Part 2, Appendix F).

In a second preferred embodiment of the present invention the polyurethane foam structure of the cushion is a Combustion Modified High Resilience (CMHR) foam. CMHR foams can be produced as either moulded foams or block foams. In common with the graphite/PU foams described above, the CMHR foams are high resilience PU-based foams. The main flame retardant in the CMHR foam is Melamine powder, although additional flame retardant

additives, such as chlorinated phosphate esters, are also usually present. CMHR foams are designed to meet the flammability requirements of Schedule 1, Part 1 of 'The Furniture and Furnishings (Fire) (Safety) Regulations 1988 (amended 1989) for use in domestic furniture in the United Kingdom. CMHR foams will also meet the requirements of the Federal Aviation Authority's 'Vertical strip test' described above, but an aircraft seat cushion formed from a CMHR foam typically fails to satisfy the requirements of the 'Kerosene burner test'. To enable the CMHR foam cushions to satisfy 'Kerosene burner test' the foam needs to be covered and tested with a suitable fire-blocking layer, as discussed below.

As previously mentioned, the foams present in the foam structure, i.e. the low-density flame retardant foam and the flame retardant polyurethane foam, must meet the requirements of the Federal Aviation Authority 'Vertical strip test'. If the foam passes this test, but an aircraft seat cushion prepared from the foam fails 'Kerosene burner test', then the foam structure of the cushion can be provided with an outer fire blocking layer which enables the composite aircraft seat to meet the prescribed requirements. The fire-blocking layer (FBL) may be a foam, fabric or foil material which is provided on the outer surface of the foam structure. Preferably, it is an interliner between the foam structure and the outer fabric cover. The FBL may be adhered to the surface of the foam structure, used as a loose cover or laminated or quilted to the inner surface of the fabric cover. Illustrative examples of suitable foam materials that can be used to form a FBL include post-treated PU foam, graphite/PU foam, neoprene foam and silicon foam. A fabric-based FBL can be prepared from either a woven, non-woven, felt or blend of any

suitable fire-blocking fabric material. Illustrative examples of suitable fabric materials include the following: flame retardant cotton, para-aramids (e.g. Kevlar), meta-aramids (e.g. Nomex), Pre-Ox Pan, Basofil, and glass fibre.

According to a second aspect of the present invention there is provided an aircraft seat comprising a cushion as hereinbefore defined.

According to a third aspect of the present invention there is provided a method of manufacturing a cushion suitable for use in an aircraft seat as hereinbefore defined, said method comprising the steps of:

(i) fabricating the low-density flame retardant foam into the desired configuration;

(ii) coating the surface of said low-density flame retardant foam with a sealant barrier; and

(iii) applying the flame retardant polyurethane foam to the sealing barrier.

As previously mentioned, the sealant barrier may be applied as a film of material such as PVC or polyethylene. Preferably, however, the sealant barrier is applied as a "spray-on" coating of polyurethane or PVC, with polyurethane being most preferred.

Once formed the cushion will usually be provided with an outer fabric cover prior to use.

If necessary, a suitable fire-blocking layer can be provided on the surface of the foam structure (preferably as an interliner between the foam structure and the fabric cover).

In order that the present invention may be more readily understood specific embodiments thereof will now be described, by way of example only, with reference to the following drawings, in which:-

Figure 1 is a diagrammatic illustration of a cross-sectional view taken through the foam structure of a first embodiment of an aircraft seat cushion according to the invention; and

Figure 2 is a diagrammatic illustration of a cross-sectional view taken through the foam structure of a second embodiment of an aircraft seat cushion according to the invention.

In the following description of the figures like reference numerals are used to denote like parts where appropriate.

Referring to Figure 1, the foam structure 101 comprises an inner core of Basotect™ Melamine foam 102 (BASF) surrounded by a layer of Metzoprotect™ graphite/PU foam (Kay-Metzeler Limited, U.K.). Disposed at the interface between the Melamine foam 102 and the graphite/PU foam 103 is a sealing barrier 104 in the form of a spray-on coating of polyurethane sealant. In an alternative embodiment the invention, the sealing barrier 104 is a spray-on coating of polyvinylchloride.

The foam structure 101 is shaped and contoured to fit into the frame of a standard aircraft seat. Specifically, the lower surface 105 and the rear edge 106 are shaped to fit into a correspondingly shaped recess in the frame of the aircraft seat whilst the upper surface 107 is shaped to define the sitting or "seat" portion of the aircraft seat.

The foam structure 101 is provided with a fabric cover (not shown) prior to placement into the frame of an aircraft seat.

The foam structure differs from that of the conventional aircraft seat cushions in that a proportion of the graphite/PU foam is replaced by the Melamine foam 102, which has a much lower density. As a consequence, the weight of the foam structure, and hence the final cushion, is substantially reduced.

The construction of the foam structure 101 shown in Figure 1 is preferred because the higher density graphite/PU foam provides the necessary rigidity and support to the lower density Melamine foam. In particular, the provision of an upper surface 107 formed of graphite/PU foam, as well as the lower surface 105, the rear edge 106, the front edge 108 and the side edges (not shown), is necessary in order to provide the sufficient support and comfort to a person sitting in the seat. Thus, the provision of a foam structure formed in this way enables a lightweight cushion to be produced without any detriment to the level of comfort and support provided.

In an alternative embodiment, the low-density Melamine foam also forms the lower surface 105 as well as the inner core of the foam structure. Hence, the

inner core and the graphite/PU foam forms only the edges and the upper surface 107 of the foam structure. This construction also provides a cushion capable of providing sufficient support and comfort.

The foam structure 101 is manufactured by initially cutting and fabricating the low-density Melamine foam 102 into the desired shape. The Melamine foam 102 is then coated with the spray-on polyurethane sealant barrier 104. The coated Melamine foam (102,104) is then placed into the mould for the final aircraft seat cushion and the liquid graphite/PU foam is applied around the coated Melamine foam. The liquid graphite/PU foam is then allowed to cream, rise, gel and cure to form the outer layer 103.

Both the low-density Basotect™ Melamine foam 102 and the Metzoprotect™ graphite/PU foam 103 meet the prescribed requirements of the Federal Aviation Authority's 'Vertical strip test' and an aircraft seat cushion comprising the foam structure shown in Figure 1 also satisfies the requirements of the 'Kerosene burner test'.

A second embodiment of a foam structure according to the present invention is illustrated diagrammatically in Figure 2. The embodiment shown in Figure 2 is similar to the embodiment illustrated in Figure 1 insofar as the foam structure 201 is correspondingly shaped and comprises of an inner core of low-density Basotect™ Melamine foam 102 provided with a spray-on polyurethane sealing barrier 104 on the outer surface thereof. However, instead of the graphite/PU foam layer 103 present in the foam structure 101, the second

embodiment of the foam structure 201 comprises a layer of CMHR foam 203. In common with the graphite/PU foam layer 103 described above in reference to Figure 1, the CMHR foam provides the necessary support and rigidity to the foam structure 201 and hence, the final cushion.

The CMHR foam satisfies the requirements of the Federal Aviation Authority's 'Vertical strip test', but an aircraft seat cushion formed in accordance with the prescribed requirements fails the 'Kerosene burner test'. For this reason, a fire-blocking layer 210 is provided on the outer surface of the foam structure 201.

It shall be understood that the description of the two embodiments shown in Figures 1 and 2 is for the purpose of illustration only and should not be construed as limiting the scope of the present invention in any way.